CLAIMS

We claim:

1. An optical switch comprising:

an array of optical input channels each capable of carrying an associated input light beam;

an array of output channels;

an array of beam monitoring elements;

a switching array for coupling selected input channels to selected output channels enabling the switching of each input light beam to one of a plurality of output channels;

a beam splitter optically interposed between the switching array and the array of output channels to split input light beams into a monitor beam and a working beam; and

wherein each beam monitoring element measures one of the monitor beams to provide optical information used for adjusting the switching array such that the working beams enter the output channels having desired optical characteristics.

2. An optical switch as in Claim 1 wherein the beam splitter comprises a partially reflective surface optically positioned such that the monitor beam is reflected by the partially reflective surface onto the array of beam monitoring elements, and such that the working beam passes through the partially reflective surface onto the array of output channels.

3. An optical switch as in Claim 1 wherein the optical information provided by the beam monitoring element enables the adjustment of the working beam to adjust for positional misalignment errors and angular misalignment errors so that the working beams enter the output channels having desired optical characteristics.

4. An optical switch as in Claim 3 wherein a single beam monitoring element measures optical power in a monitor beam such that both the angular misalignment and the positional misalignment of a working beam can be detected and adjusted.

5. An optical switch as in Claim 3 wherein each beam monitoring element includes means for measuring the monitor beam thereby determining the positional misalignment and angular misalignment in the working beam.

6. An optical switch as in Claim 1 wherein the beam monitoring elements provide optical information used to adjust the working beams such that the beams enter the output channels having a desired optical power.

7. An optical switch as in Claim 6 wherein the desired optical power is an optimal amount of optical power.

8. An optical switch as in Claim 1, wherein the beam splitter is included as part of a rhomboid prism assembly which is positioned such that the monitor beams and the working beams exit the rhomboid prism assembly substantially parallel to each other.

9. An optical switch as in Claim 1, wherein the switching array comprises, in combination, control circuitry, a first movable reflector array, and a second movable reflector array, each array including a plurality of movable reflectors, the position of which is controlled by control circuitry, wherein the reflectors are positioned such that the input light beams pass onto the first movable reflector array, and such that the plurality of input light beams are reflected from the movable reflectors of the first reflector array onto the reflectors of the second reflector array enabling the switching of the input light beams to selected output channels.

10. An optical switch as in Claim 9 further including:

a first lens array including a plurality of first lenses, positioned such that the plurality of input light beams pass through the plurality of first lenses onto the switching array; and

a second lens array including a plurality of second lenses, positioned such that the working beams pass through the plurality of second lenses into the output channels.

11. An optical switch as in Claim 10 wherein the working beams enter the output channels having optimized beam power.

12. An optical switch as in Claim 11 wherein the control circuitry, using information provided by the beam monitoring elements, adjusts the angular misalignment and the positional misalignment of the working beams.

13. An optical switch as in Claim 10 wherein each beam monitoring element comprises:

a monitor lens;

a monitor fiber;

a detector element;

wherein the monitor beam passes through the monitor lens into the monitor fiber and exits the monitor fiber where the optical power of the monitor beam is measured by the detector element.

14. An optical switch as in Claim 10 wherein the monitor lenses of the beam monitoring elements are included as part of the second lens array.

15. An optical switch as in Claim 9 wherein the plurality of output channels comprise a plurality of output fibers.

16. An optical switch as in Claim 15 wherein the plurality of output fibers are positioned a first distance from the partially reflective surface and the monitor lenses of

the plurality of beam monitoring elements are positioned a second distance from the beam splitter.

17. An optical switch as in Claim 16 wherein the first distance the output fibers are positioned from the beam splitter and the second distance the monitor lenses are positioned a from the beam splitter are such that the first distance is approximately the same as the second distance.

18. An optical switch as in Claim 10 wherein each beam monitoring element comprises:

a first quadrature detector element;

a second quadrature detector element; and

a second beam splitter for reflecting a portion of the light of the monitor beam into the second quadrature detector element and for passing another portion of the light of the monitor beam through the second beam splitter into the first quadrature detector element.

19. An optical switch as in Claim 18 wherein the portion of the light measured by the first quadrature detector element provides information used to determine and adjust the position of the working beam; and

wherein the another portion of the light measured by the second quadrature detector element is used, in conjunction with the portion of the light measured by the first quadrature detector element, to provide information used to determine and adjust the angle at which the working beam enters the output channels.

20. An optical switch as in Claim 10 wherein each beam monitoring element comprises:

a first light block having formed therein, a first aperture;

a monitor lens; and

a detector element for detecting the monitor beam after it passes through the first aperture and passes through the monitor lens wherein the monitor beam provides working beam positional misalignment information.

21. An optical switch as in Claim 20 wherein the detector element includes a small surface area sized such that the monitor beam passing through the first aperture and passing through the monitor lens and impinging on the small detector element provides information regarding the angular misalignment of the working beam.

22. An optical switch as in Claim 20 the detector element comprises:

a second light block positioned to block a monitor beam from impinging on the detector element;

a second aperture formed in the second light block to reveal a surface area of the detector element, enabling the monitor beam reach the detector element;

wherein the second aperture is sized to reveal a surface area on the detector element such that the monitor beam passing through the first aperture and passing through the monitor lens and impinging on the small detector element provides information regarding the angular misalignment of the working beam.

23. An optical switch as in Claim 22 wherein the first aperture has approximately the same cross-sectional dimensions as the monitor beam; and wherein the second aperture has approximately the same cross-sectional dimensions as the optical mode of the monitor beam.

24. An optical switch as in Claim 22 wherein the first aperture has approximately the same cross-sectional dimensions as the monitor beam.

25. An optical switch as in Claim 22 wherein the second aperture has approximately the same cross-sectional dimensions as the optical mode of the monitor beam.

26. An optical switch as in Claim 20 wherein the monitor lens is positioned with respect to the detector element such that a monitor beam passing through the monitor lens is focussed on the surface of the detector element.

27. An optical switch as in Claim 20 wherein the monitor lens is positioned with respect to the detector element such that a monitor beam passing through the monitor lens is not focussed on the surface of the detector element.

28. An optical switch comprising:

an array of input channels each capable of carrying an associated light beam;

an array of output channels;

an array of beam monitoring elements;

a switching array including reflector arrays for switching selected light beams received from the input channels into any of a selected plurality of output channels as output beams;

an array of rhomboid prism assemblies positioned to receive the output beams from the switching array such that a portion of the light from the plurality of output beams is reflected in the form of monitor beams, and such that another portion of the light from the plurality of output beams passes through the rhomboid prism assemblies as working beams, wherein the monitor beams are reflected such that the monitor beams and the working beams emerge from the rhomboid prism assemblies as substantially parallel beams, wherein the working beams are directed into the plurality of output channels and wherein the monitor beams are directed into the beam monitoring elements wherein they are measured and used to provide information for adjusting the working beam.

29. An optical switch as in Claim 28, wherein the array of rhomboid prism assemblies includes a plurality of rhomboid prism assemblies having a rectangular dimension.

30. An optical switch as in Claim 28, wherein each rhomboid prism assembly includes a rhomboid prism element and a triangular prism element.

31. An optical switch as in Claim 28, wherein monitor beam optical information measured by the beam monitoring elements is used to determine the angular misalignment and the positional misalignment of the working beams.

32. An optical switch as in Claim 31, wherein the beam monitoring elements include means for indirectly measuring the angular misalignment and the positional misalignment of the working beam.

33. A folded optical switch comprising:

a fiber array including a plurality of input fibers and a plurality of output fibers, wherein the input fibers and output fibers are capable of carrying an associated light beam;

an array of beam monitoring elements located physically apart from the fiber array;

a switching array comprising, in combination, a plurality of first movable reflectors, a plurality of second movable reflectors, a stationary reflector; and control circuitry operating such that a light beam input into the switching array from an input fiber can be switched to a selected output fiber;

a beam splitter interposed between the switching array and the fiber array such that a portion of the light from the light beams exiting the switching array is reflected by the beam splitter as monitor beams onto the physically apart beam monitoring elements

and such that another portion of the light from the light beams exiting the switching array passes through the beam splitter as working beams which enter the output fibers; and

wherein the beam monitoring elements measure the monitor beams and provide optical information to the control circuitry for adjusting the switching array such that the working beams enter the output fibers having the desired optical characteristics.

34. An optical switch as in Claim 33 wherein the beam splitter comprises a partially reflective surface.

35. An optical switch as in Claim 34 wherein the beam monitoring elements measure optical power in the monitor beam such that both the angular misalignment and the positional misalignment of the working beam can be detected and adjusted.

36. An optical switch as in Claim 35 wherein the beam monitoring elements includes means for measuring optical power in the monitor beam such that both the angular misalignment and the positional misalignment of the working beam can be detected and adjusted.

37. An optical switch as in Claim 35 wherein the beam monitoring elements include two aperture beam monitoring elements.

38. An optical switch as in Claim 35 wherein the beam monitoring elements further comprise:

a monitor lens;

a monitor fiber;

a detector element;

wherein the monitor beam passes through the monitor lens into the monitor fiber and exits the monitor fiber where the optical power of the monitor beam is measured by the beam monitoring element.

39. An optical switch as in Claim 38 wherein the detector element of beam monitoring elements comprises a single detector element.

40. An optical switch as in Claim 35 wherein the of beam monitoring elements comprises include:

a first light block having formed therein, a first aperture;

a monitor lens;

a detector element;

wherein the monitor beam passing through the first aperture and passing through the monitor lens is detected by the detector element to provide working beam positional misalignment information.

41. An optical switch as in Claim 40 wherein the detector element includes a detector element having a small surface area sized such that the monitor beam passing through the first aperture and passing through the monitor lens and impinging on the small detector element provides information regarding the angular misalignment of the working beam.

42. An optical switch as in Claim 40 the detector comprises:

a second light block positioned to block the monitor beam from impinging on the detector element;

a second aperture formed in the second light block to reveal a surface area of the detector element, thereby enabling the monitor beam reach the detector element;

wherein the second aperture is sized to reveal a surface area on the detector element such that the monitor beam passing through the first aperture and passing through the monitor lens and impinging on the small detector element provides information regarding the angular misalignment of the working beam.

43. An optical switch as in Claim 40 wherein the monitor lens is positioned such that the monitor beam passing through it is focussed on the surface of the detector element.

44. An optical switch as in Claim 40 wherein the monitor lens is positioned with respect to the detector element such that the detector element receives unfocused light from the monitor beam.

45. A method for indirectly measuring and adjusting light beams output from an optical switch, the method comprising the steps of:

receiving, by the optical switch, an input light beam;

switching of the input light beam, such that the input light beam is optically coupled to one of a plurality of selected output channels;

after switching, splitting the light beam into a monitor beam and a working beam;

calibrating the optical power of the monitor beam to the optical power of the working beam;

using the detected optical power of the monitor beam, to adjust reflectors in the so that the working beam exhibits the desired optical characteristics; and

outputting the working beam.

46. The method of Claim 45 wherein the calibrating of the monitor beam to the working beam is conducted at more than one temperature.

47. The method of Claim 45 wherein the calibrating of the monitor beam to the working beam comprises the substeps of:

detecting the optical power of the working beam;

maximizing the optical power of the working beam;

initial detecting the optical power of monitor beam;

generating calibration derivative information for the monitor beam; and

storing the derivative information.

48. The method of Claim 47 wherein the step of using the detected optical power of the monitor beam, to adjust reflectors in the so that the working beam is output having desired optical characteristics comprises the substeps of:

a. operative detecting the optical power of monitor beam;

b. obtaining operative derivative information concerning the monitor beam;

c. comparing the operative derivative information with the stored derivative information;

d. where the operative derivative information is within a predetermined error tolerance of the stored derivative information, completing reflector adjustment;

e. however, where the operative derivative information is not within a predetermined error tolerance of the stored derivative information,

calculating new reflector angles in accordance with a reflector position optimization method;

adjusting reflector angles to the new reflector angles; and

repeating steps a-e until the operative derivative information is within a predetermined error tolerance of the stored derivative information, thereby completing reflector adjustment.

49. The method of Claim 48 wherein the step of calculating new reflector angles in accordance with a reflector position optimization method includes using a position optimization method selected from among the group consisting of: random walk optimization, gradient optimization, and optimization in accordance with a model.

50. The method as in Claim 45, wherein the step of adjusting the working beam includes adjusting the working beam to adjust the position and the angular alignment of the working beam.

51. The method of Claim 50 wherein achieving optimal power in the working beam does not result in optimal power of the detected monitor beam.

52. The method as in Claim 50, wherein the step of adjusting the working beam includes adjusting the working beam until it exhibits optimal power.

53. The method as in Claim 45, wherein the step of splitting the light beam into a monitor beam and a working beam includes directing the monitor beam to a position remote from the working beam, and

wherein detecting of the monitor beam is accomplished at a position remote from the working beams.

54. The method as in Claim 45, wherein the step of splitting the light beam includes reflecting the monitor beams such that they are substantially parallel to the working beams.

55. A method as in Claim 45 wherein the step of switching the input light beam includes switching the beam using two reflectors.

56. The method of Claim 55 wherein the detecting the monitor beam and adjusting the working beam is accomplished using a single photodetector.